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A COMPARISON OF MEAT YIELDS AND MECHANICAL DESHELLING CHARACTERISTICS OF MOLTED AND UNMOLTED SPECIMENS OF ATLANTIC SNOW CRAB (*CHIONOECETES OPILIO*)

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ABSTRACT

G. G. Sims, W. E. Anderson and C. E. Cosham. 1980. A Comparison of Meat Yields and Mechanical Deshelling Characteristics of Molted and Unmolted Specimens of Atlantic Snow Crab *(Chionoecetes opilio)*. Can. Tech. Rep. Fish. Aquat. Sci. 908, 8 pp.

A comparison was made between meat yields from unmolted (hard shelled) and molted (soft shelled) specimens of Atlantic snow crab *(Chionoecetes opilio)*. Some characteristics of minced meats obtained by the mechanical deshelling of materials taken from these two types of specimens were assessed, the percentage yields of various components of the crabs and of hand and mechanically separated meats were determined, the minced meats were assessed by a taste panel for objectionable shell particles and the proximate composition was also determined. The maximum meat yield from the unmolted specimens (using a combination of hand and mechanical operations) was 42%, which was substantially higher than the 35% obtained from molted crabs. The minced meats contained sufficiently low concentrations of shell particles so as to be acceptable to the taste panel and chemical analyses showed that the undesirable solids contents were substantially lower than those previously reported for minced rock crab meats. It was inferred that the shell content of minced crustacean meats correlate directly with the hardness or brittleness of the shell of the raw material.

RÉSUMÉ

On a comparé la quantité de chair produite par des spécimens de crabe des neiges *(Chionoecetes opilio)* avant la mue (carapace dure) et aprés la mue (carapace molle). On a évalué certaines caractéristiques de la chair hachée obtenue par décorticage méchanique de matière première provenant de ces deux types de spécimens, on a déterminé le rendement en pourcentage des diverses parties des crabes et des crabes et des chairs séparées manuellement ou mécaniquement, un jury de dégustation a goûté les chairs hachées pour y rechercher la présence de particules indésirables de carapace, et on a aussi déterminé la composition approximative de la chair. Le rendement maximal des spécimens à carapace dure (avec combinaison de décorticage manuel et mécanique) était de 42%, pourcentage nettement supérieur aux 35% obtenus avec les crabes à carapace molle. Les chairs hachées présentaient une teneur assez faible en particules de carapace pour être jugées acceptables par le jury de dégustation, et les analyses chimiques ont montré que la teneur en matières solides indésirables était nettement inférieure aux résultats obtenus sur la chair hachée de crabe commun. On déduit de ces travaux que la teneur en particles de carapace de la chair hachée de crustacés est en corrélation directe avec la dureté ou la fragilité de la carapace de la matière première.

INTRODUCTION

The Canadian East Coast fishery for queen crab *(Chionoecetes opilio)*, now known as the Atlantic snow crab because of export regulations, began in 1967 and has grown rapidly during the past decade. Since the beginning of this industry there has been a marked increase in the proportion of molted crabs in commercial catches. This may be regarded as a predictable consequence of the development of this fishery. In many decapod crustaceans, including the snow crab (Watson, 1971), the frequency of molting decreases with increasing age. As the new industry develops, the increased fishing pressure brings about a decrease in the proportion of older crabs in the stock. Thus, the initial standing stock of older specimens is reduced and a balance is established between mortality from commercial fishing pressure and recruitment to the fishing stock. At that time the mean age of the stock will be lower than that of the previously untapped resource and (provided that the species is not overexploited) an equilibrium should be reached. As a consequence of the mean age reduction of the stock, the probability of catching younger molted crab increases. The seasonal aspect of the molting process in relation to the timing of the fishing season is also an important factor in this respect. The increasing proportion of molted crabs in their catch is of consequence to the fisherman and to the industry because these specimens provide both a lower quality and a lower yield of meat and they are protected by law, a measure necessary for the continuance of a healthy fishery.

This work compares various yields from unmolted and molted specimens. The use of mechanical separators has been suggested for the production of minced crustacean meats by several workers (see for example Finnegan, 1972, and Wojtowicz and Dyer, 1975). In this work a Baader 694 mechanical separator (Dennis, 1972) was used to assist in the estimation of the maximum recoverable meat yields and to indicate alternate uses of various raw materials. In this separator the raw material is pressed between a belt and a perforated drum so that the meat is squeezed through to the inside of the drum where it is removed by a screw device. Previous work in this laboratory with other crustaceans and by Guptill (1974) with Atlantic snow crab, has indicated that the size of perforations in the drum influences the quantity of undesirable solids in the product (i.e. larger perforations result in higher contents) but does not appreciably affect the overall meat yield. Therefore, in order to produce meats with the lowest undesirable solids contents, the Baader 694 used in this work was equipped with a drum having 1.2 mm perforations. The main factor controlling the meat yield is the belt pressure but excessive tension will also cause large quantities of undesirable solids to pass into the minced meats. Thus the best combination is a drum having small perforations and operated at moderate pressure.

EXPERIMENTAL

Specimens of unmolted and molted snow crab were obtained from a commercial catch off Shippegan, N. B. The unmolted and molted crabs (locally referred to as "brown" and "white" respectively, due to the differences in the colour of the shells) were handled as separate groups for parallel comparisons throughout this study. The molted specimens chosen for this work had shells of sufficient hardness to be approaching commercial acceptability. The live weight of each group was recorded and the crabs were then sectioned. The sections were brushed, washed, reweighed and then cooked in boiling water for 6½ minutes, cooled in cold running water and drained. They were again weighed and then each group of sections was further divided into three subgroups.

The first subgroups were weighed and the meats were removed by hand operations. From this stage the leg tips (from which the meat is not readily removed by hand) were collected separately and weighed. The leg shells, shoulder shells and leg tips were then processed as separate groups by the Baader 694 mechanical separator.

The weighed sections composing the second subgroups were passed through the separator as whole sections.

The third subgroups were weighed, the sections were broken into shoulders and legs (including claws) which were also weighed and these were mechanically deshelled as separate lots. In a commercial operation the leg meats and claw meats would not be handled together nor processed by a mechanical separator since these are clearly the choice parts of this species. However, for comparisons of various yield values, the claws and legs were handled together in this present study.

The minced crab meats were rated for the presence of undesirable particles (shell, chitinous connective tissues, etc.) by a taste panel composed of laboratory personnel with experience in assessing similar products. Each sample was rated for any grittiness (or chewiness) imparted by shell fragments (or soft undesirable materials) using a scoring schedule as follows: 1 - no grittiness (or chewiness), 2 - nil to slight, 3 - slight, 4 - slight to moderate, 5 - moderate, 6 - moderate to severe and 7 - severe. The panel members were also requested to indicate whether any observed grittiness was sufficient to render the samples objectionable.

Proposed tolerance limits for shell contents had been developed using shell fragments derived from specimens of rock crab (*Cancer irroratus*) (Sims and Anderson, 1976). Since the shell of the rock crab appears substantially harder and more brittle than the Atlantic snow crab shell, it was speculated that snow crab shell

fragments may not be as objectionable as those of rock crab. To test this possibility a series of samples was prepared for taste panel assessment. Hand separated (shell-free) snow crab meat was minced in a silent cutter and water was added in order to obtain a texture and moisture content similar to meats obtained from a mechanical separator. From this, eight samples were prepared. Two of these were controls with no shell added, three had snow crab shell fragments added at three concentrations and the remaining three had rock crab shell fragments added at the same concentrations and in similar size categories. The shell fragments were prepared by digesting the organic material (as in a shell determination) and then drying, grinding and sieving the resultant fragments. The samples were individually coded and assessed by the taste panel as described above.

Moisture contents of the samples were determined by drying at 104 C for 18 hours. The dried samples were pulverized and retained for ash, crude fat and crude protein determinations. Ash and crude fat were determined by A.O.A.C. procedures 18.021 and 7.045 respectively (A.O.A.C., 1975). Total nitrogen values determined by A.O.A.C. procedure 47.023 (A.O.A.C., 1975) were multiplied by 6.25 to obtain crude protein values. For the estimation of phosphorus content, dry samples were ashed at 550 C, dissolved in nitric acid and diluted to a known volume (eg 25ml). A suitable aliquot of this was digested with perchloric acid and phosphorus was then estimated by the colorimetric method employing the molybdenum blue complex. Shell and total undesirable solids values were determined by the methods of Sims *et al*, 1977.

RESULTS AND DISCUSSION

Table 1 shows the yields of the various parts of unmolted and molted snow crab. With the exception of the leg tips, the unmolted crabs consistently gave substantially higher yields than the molted specimens. Differences in meat yields could be due to three main contributing factors; i) differences in the shell weight, ii) differences in fluid content or iii) differences in meat content. Thus, a point of interest was to determine what proportion of these higher segment yields are actually reflected in higher meat yields. The fluid loss on breaking the sections into legs and shoulders was 1.7% and 9.0% of the live weight from the unmolted and molted specimens respectively. Based on the section weight these fluid losses were 2.5% and 14.0% respectively.

The various raw materials which were deshelled on the Baader 694, the yields of minced meats, and the yields from hand processing are described in Table 2. The yields are expressed on the live weight of the snow crab, on the cooked section weight and on the deboner input weight. From the hand separation process the shoulder meat yields were not appreciably different from each other. However, the unmolted crabs gave an appreciable higher meat yield from the legs and claws. Thus the higher yield of legs (plus claws) from the unmolted specimens was carried through to give a higher meat yield. The similar yields of shoulder meats could be attributed to either a higher shell content in the unmolted crabs or to difficulties in separation of the meat from these specimens. Further evidence on this topic was obtained from the mechanical deshelling experiments.

With the exception of the leg tips, the unmolted specimens gave substantially higher minced meat yields relative to the live crab weight and relative to the cooked section weight. The relative magnitude of these yields indicates that the differences are accounted for partly during the manipulations which bring the live crab to the cooked section stage and partly during the meat recovery operation. The meat yield from the mechanical separation of refuse from hand separated shoulders and legs was much higher from unmolted crabs. This suggests that the hand picking of the molted (soft shelled) crab is more efficient and also shows that this factor was instrumental in showing similar yields of hand picked shoulder meat from both unmolted and molted specimens.

In comparing the total meat yields, the small difference in shoulder yield was almost completely accounted for by the increased meat yield from the unmolted specimens. On the other hand, the large difference in the yields of legs was about equally attributed to the higher meat contents in the unmolted crabs and to the higher fluid contents of the molted crabs. These observations were verified by analyses of cooked shoulders and legs (plus claws). As suggested, the shoulders of unmolted and molted specimens had similar moisture contents while the legs of the unmolted specimens had a moisture content 5% lower than that of the molted specimens. It was further noted that although the leg tips comprised a smaller percentage of the section weight in the unmolted crabs, this again appears to be a consequence of the fluid content of the molted crabs, as the meat yields were similar from both specimen types.

Table 3 shows a comparison of the total meat yields obtained from the unmolted and molted crabs by various combinations of hand processing and mechanical deshelling techniques. The mean yield from the unmolted crabs was 41.8% as opposed to only 34.6% from the molted crabs. This total difference of 7% (or 17% relative) is quite substantial. However, a more meaningful result is obtained if the moisture content of these meats is considered so that overall yields are compared on the basis of the solid components. Thus the higher moisture content of the meats from molted sp[illegible]ens reflected a reduction in yield of 26[illegible] (relative) based on solid components.

The mean grittiness score for the twelve samples assessed was 1.4, indicative

of nil to slight grittiness. The meat from group UM-5 received the only objectionable rating (from 1 of a total of 4 panelists). This meat was recovered by deshelling refuse from the hand processing of leg shells of the unmolted crabs. The shell content of this sample was subsequently found to be 1.65% on a dry weight basis, which was more than double the shell content of any of the other samples.

The samples with similar concentrations of snow crab and rock crab shell fragments added, were given similar ratings for grittiness. Of the three samples of each shell type, each rated by 6 panelists, both groups of samples received 8 objectionable ratings from the total 18 scorings. This brief assessment was not intended to resolve any fine differences but it does indicate that similar concentrations of snow crab shell fragments caused similar effects on taste panel acceptance. Thus, even though the rock crab shell is more brittle, the snow crab shell is able to create unpleasant sensations to the palate and thus result in similar unfavourable panel reactions.

The results of chemical analyses of the minced crab meats and hand separated meats are given in Table 4. All meats from unmolted specimens (including hand separated meats) had lower moisture contents (mean difference 1.5% moisture) and correspondingly higher protein contents (mean differences 1.7%) than similar meat from molted crabs. The shell contents of all these samples, except the meat obtained by the mechanical deshelling of refuse from the hand separation of leg and claw meats from unmolted specimens, were considerably lower than the recommended tolerance for minced rock crab meat. These shell contents were also substantially lower than levels in similarly produced minced rock crab meat. The shell contents in minced meats from the unmolted specimens were always higher (often substantially so) than the meats from their molted counterparts. This suggests a sequence of shell contents in minced crustacean meats with rock crab > unmolted snow crab > molted snow crab. This also reflects the sequence from the very brittle shell of the rock crab to the "soft" pliable shell of the molted snow crab, thereby confirming the suspected correlation between the brittleness of the exoskeleton and the shell content of the minced meats.

CONCLUSION

The comparison of unmolted and molted snow crab confirmed that there is substantially less meat yield from molted specimens. Upon breaking the sections into legs and shoulders there is a loss of about 2.5% of the section weight from unmolted specimens and a loss of 14% from molted crabs. Similar trends were seen throughout the handling of these two groups. It must be emphasized that <u>the yields reported in this work were obtained by meticulous methods and it is therefore unlikely that commercial processing will realize such high values</u>. It was estimated that the maximum recovery of meat from the unmolted and molted crabs was 42% and 35% respectively. This is a reduction in meat yield of 17% relative to the yield from unmolted crabs. These total meat yields include the use of mechanical separator at some stage. From the hand operation, the yields were 30% and 26% for unmolted and molted crabs respectively. This is a 13% relative decrease in the yield. On the basis of total solid constituents, the yield differences are even larger. Since the molted specimens also have meats which are soft and lacking in flavour and therefore tend to lower the overall quality of the product, these yield figures add further weight to the arguments against their harvest. It must also be considered that the molted specimens used in this work were approaching commercial acceptability. If more recently molted (i.e. softer shelled) crabs had been used it would be expected that these differences would be even greater.

High yields and acceptable quality minced snow crab meats were obtained by the mechanical deshelling of cooked sections, legs, shoulders and leg tips. It must be remembered, however, that these minced meats lack the texture and appearance of hand separated meats and they tend to have substantially higher moisture contents. The smaller particle size (and therefore increased surface area) also permits much more rapid deterioration of the quality. The use of such meats will consequently be restricted to novel or less traditional products. The above figures show that the use of a mechanical separator at some stage could substantially increase the total meat yield. The minced meat yields of 19% and 53% from hand separated leg and shoulder shells respectively show that even the refuse materials still contain a significant quantity of meat. However, the deshelling of refuse has been characterized by poor quality minced meats and considerably higher undesirable solids contents. Therefore, increased yields could be best realized by the mechanical deshelling of whole shoulders.

It is encouraging that the shell contents of these minced meats were considerably lower than recommended tolerance levels and also lower than levels which have been previously reported in minced rock crab meats prepared in a similar manner. It was also concluded that the quantity of shell fragments which pass through the separator into the meat is a function of the hardness of the shell. The softer shelled specimens give minced meats with very low shell contents. However, even the relatively soft snow crab shell is quite capable of rendering a product objectionable at concentrations similar to objectionable levels of the brittle rock crab shell.

The proximate composition of the minced snow crab meats were typical of similar minced crustacean meats, having

elevated moisture contents (as compared to hand separated meats) due to water squeezed from the "refuse" during the mechanical deshelling. This was reflected by correspondingly lowered concentrations of the components of the solid fraction.

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Cooked sections	[illegible]	[illegible]		
Shoulders	16.9	13.9	24.7	21.7
Legs plus claws	49.5	41.1	72.7	64.3
Leg tips	4.7	5.5	6.9	8.6

UM-3	Legs plus claws	28.7	42.2	58.1
M-3	Legs plus claws	23.4	36.6	56.9
UM-4	Shucked shoulder shells	3.1	4.6	52.7
M-4	Shucked shoulder shells	1.0	1.6	29.0
UM-5	Shucked leg shells	5.8	8.6	18.9
M-5	Shucked leg shells	3.4	5.3	12.9
UM-6	Leg tips	2.5	3.6	52.6
M-6	Leg tips	2.9	4.5	52.5
UM-HS-7	Shoulders	11.0	16.1	-
M-HS-7	Shoulders	10.5	16.4	-
UM-HS-8	Legs plus claws	18.6	27.3	-
M-HS-8	Legs plus claws	14.8	23.1	-

*All "UM" Groups are unmolted and all "M" Groups are molted crabs.
HS refers to hand separated meats. All other values are for mechanically separated meats.

Difference-absolute	8.4	6.5	6.9	7.3
-relative	20.5	14.9	16.9	17.4
Solid Components				
-unmolted	7.8	7.6	6.8	7.4
-molted	5.8	5.6	5.0	5.5
Difference-absolute	2.0	2.0	1.8	1.9
-relative	25.6	26.3	26.5	26.1

UM-3	1.3	83.5	1.61	14.7	0.27	0.20	0.30
M-3	1.0	85.5	1.66	12.4	0.31	0.17	0.28
UM-4	1.0	85.7	1.75	11.7	0.28	0.14	0.70
M-4	1.5	86.5	1.81	11.0	0.34	0.14	0.30
UM-5	2.3	86.7	1.64	11.2	0.30	0.14	1.65
M-5	1.3	87.2	1.43	10.8	0.37	0.13	0.73
UM-6	1.8	85.8	1.57	11.5	0.26	0.12	0.78
M-6	1.5	87.7	1.76	9.8	0.32	0.13	0.24
UM HS-7	-	80.2	1.51	17.9	0.41	0.19	-
M HS-7	-	81.8	1.71	15.7	0.57	0.19	-
UM HS-8	-	78.4	1.39	19.9	0.44	0.21	-
M HS-8	-	79.9	1.61	18.0	0.49	0.24	-

*All "UM" Groups are unmolted and all "M" Groups are molted crabs; "HS" refers to hand separated meats.
**A mean grittiness score of 2.5 represents borderline acceptability. Lower scores generally represent an acceptable product.